

Predictability of an ice-free Arctic using the CESM Large Ensemble

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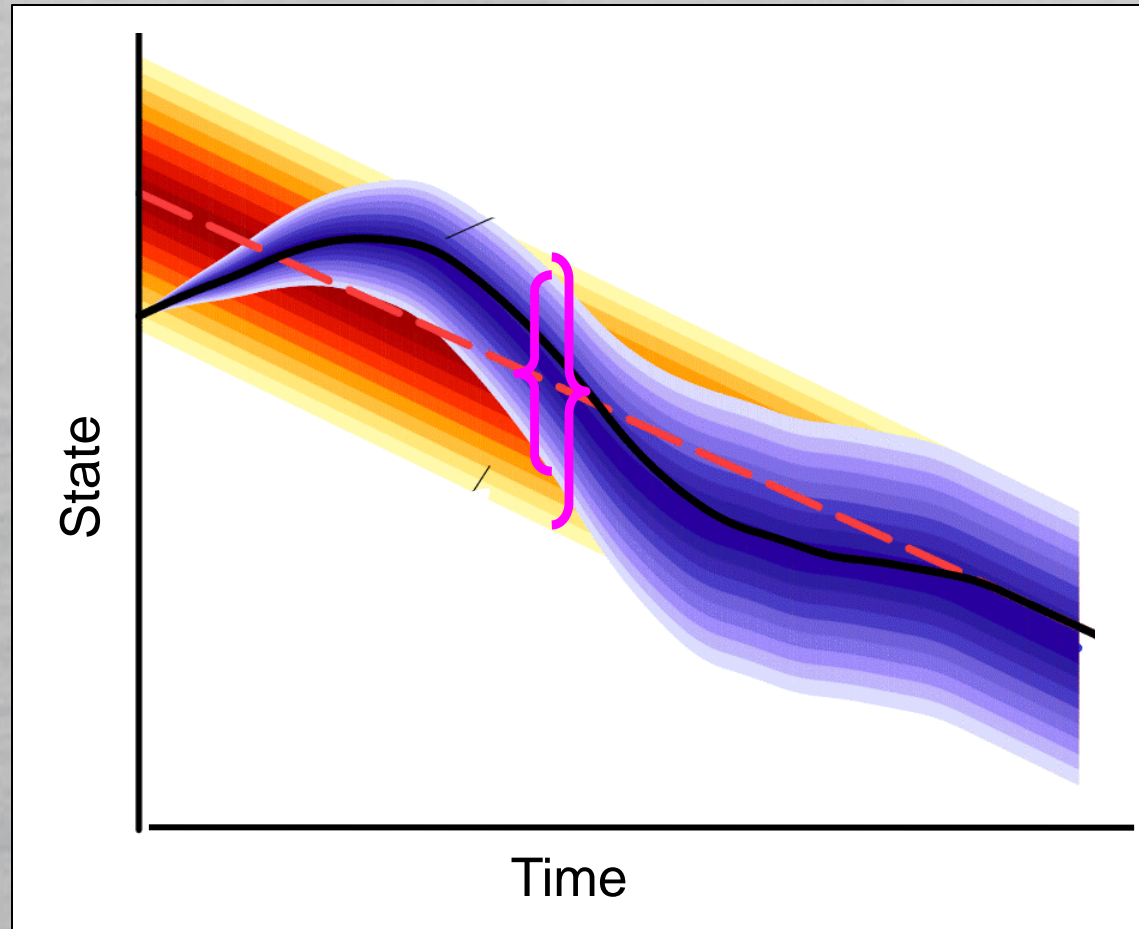
Kinds of Predictability

Of the First Kind:

- Initial value problem
- Sensitive dependence on initial conditions limits predictability
- Timescale depends on system

Of the Second Kind:

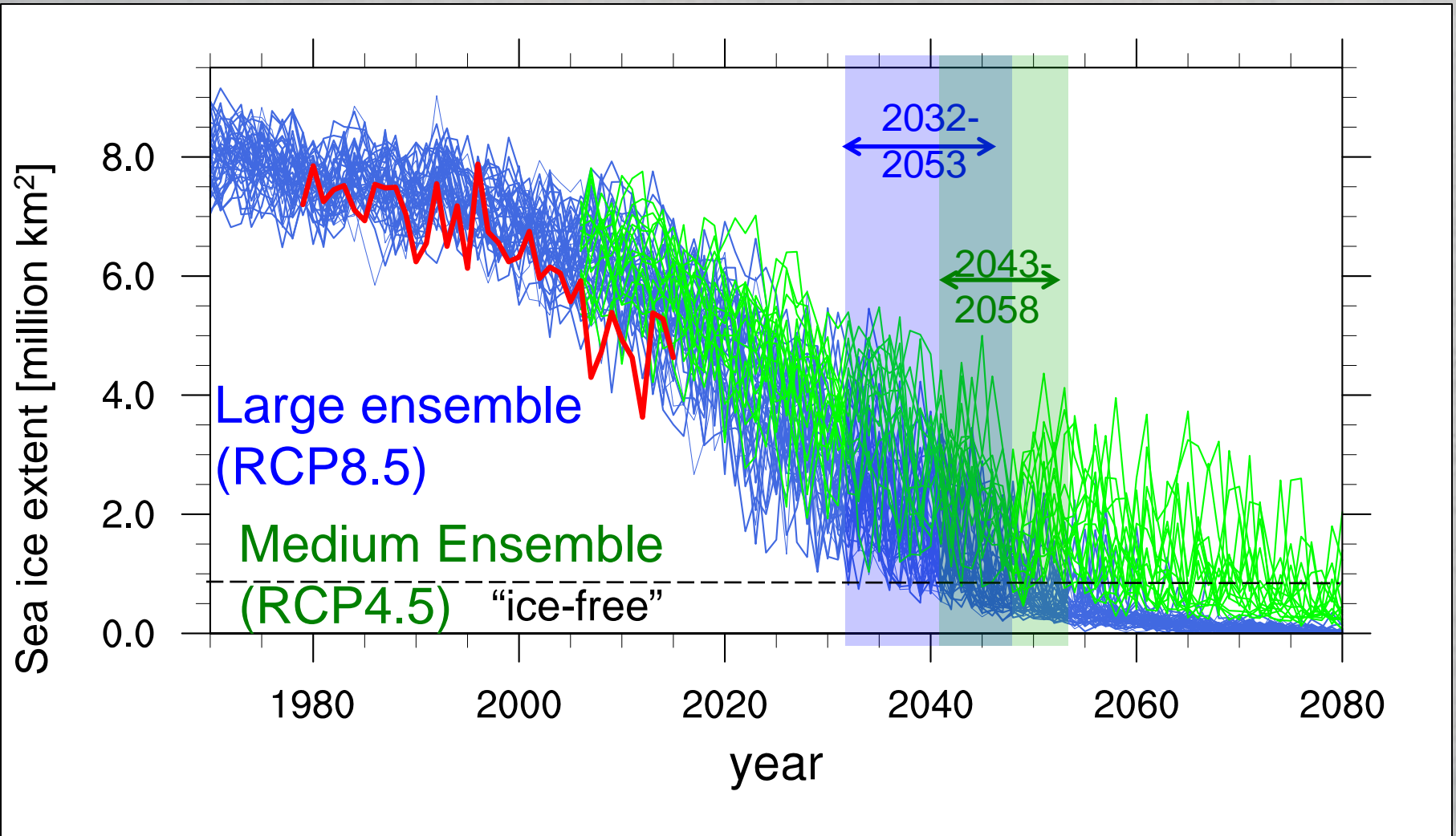
- Boundary value problem
- Prediction of statistical properties of the climate system subject to some external forcing



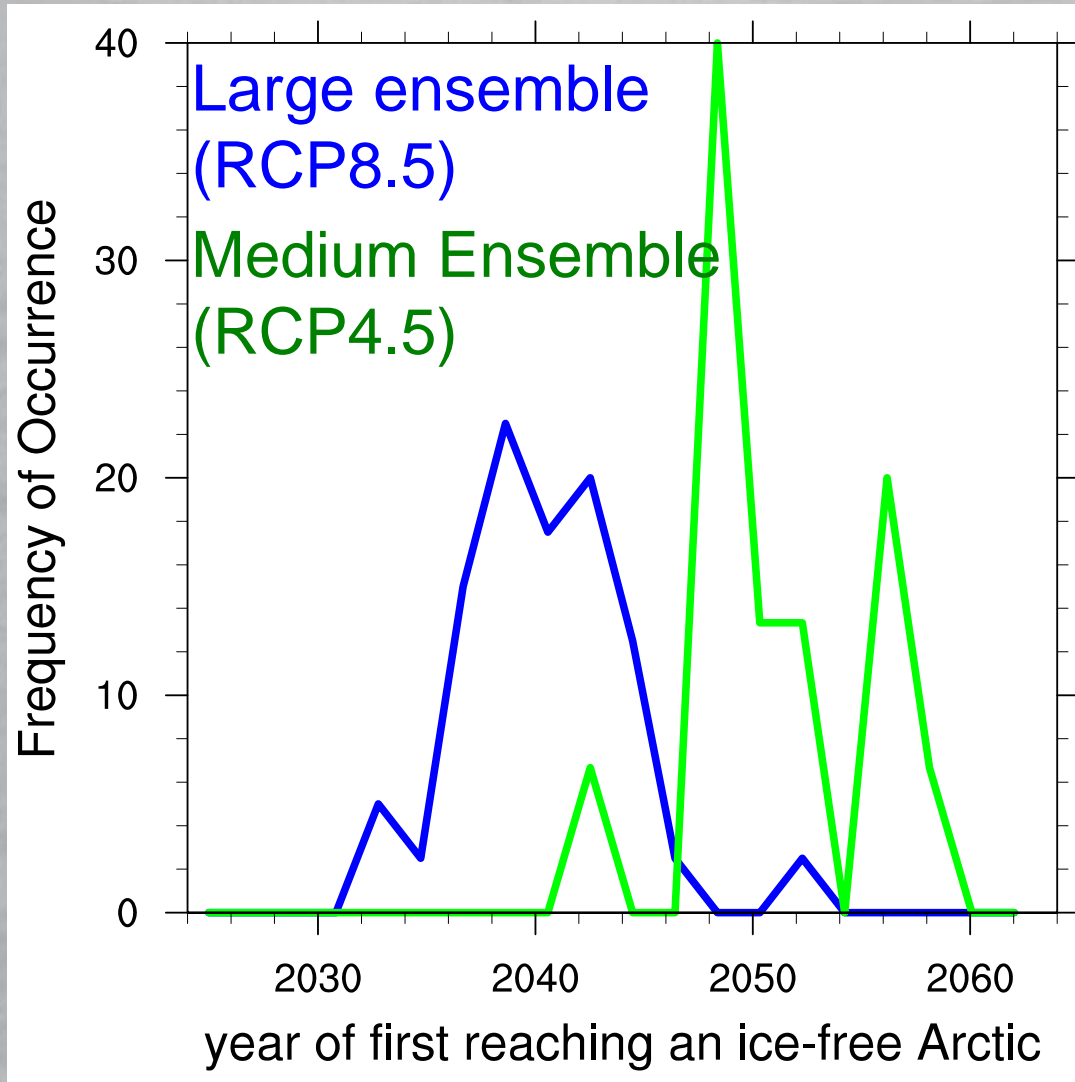
(Adapted From Branstator
and Teng, 2011)

Slide courtesy of Marika Holland

When will we first see an "ice-free" Arctic Ocean in September?

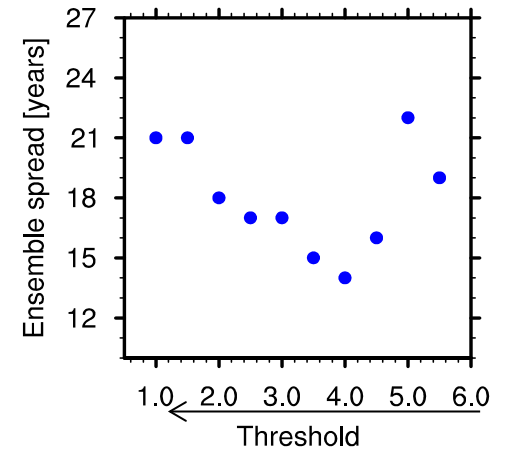
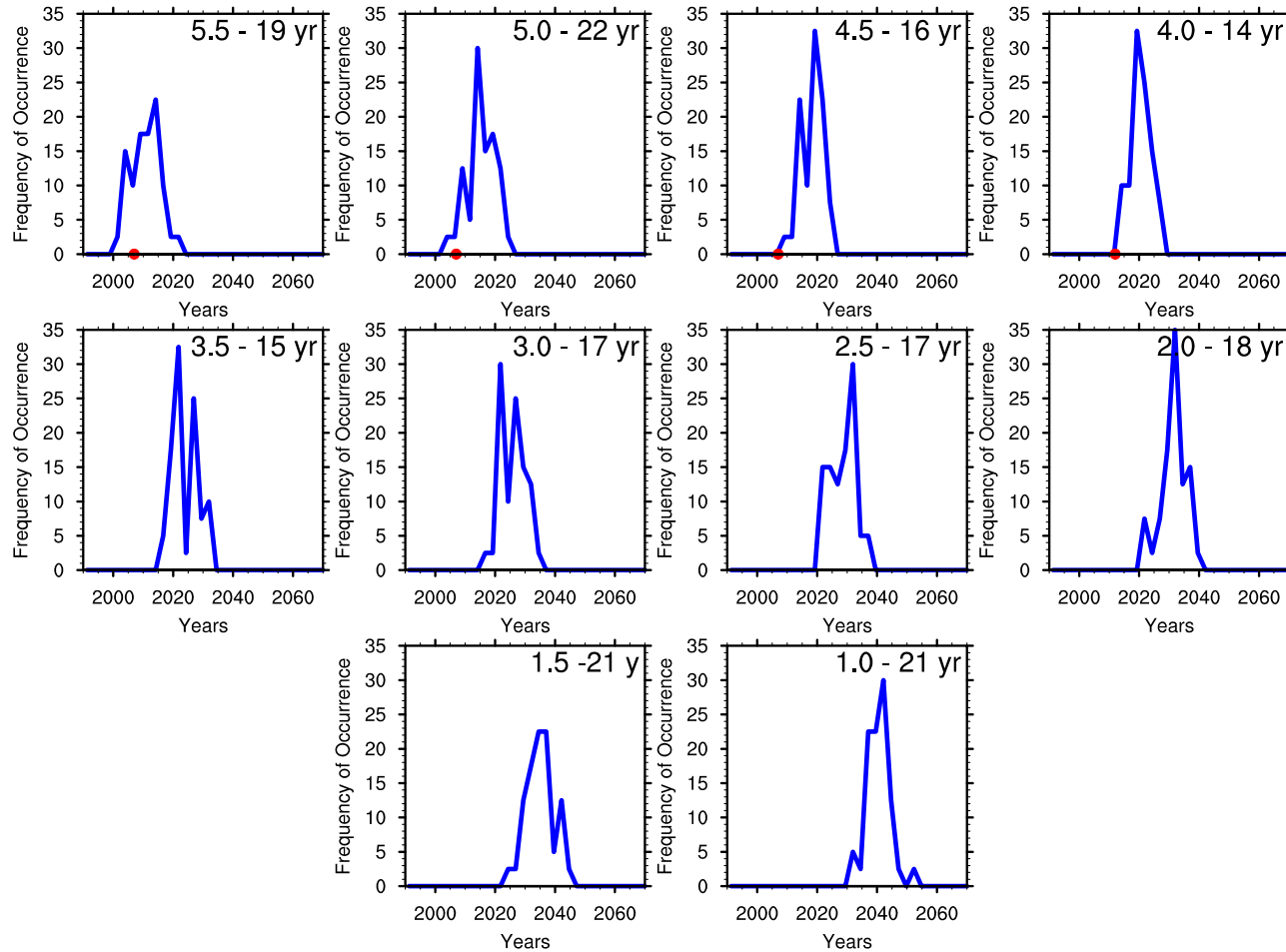


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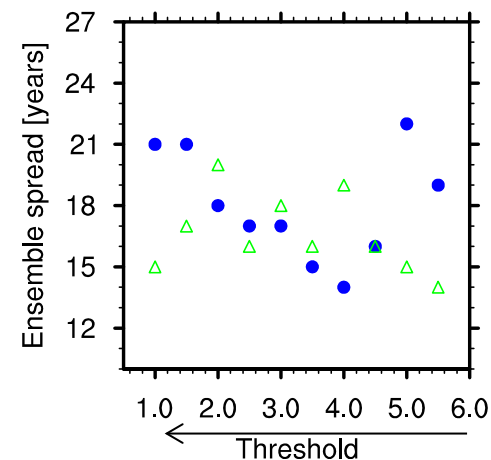
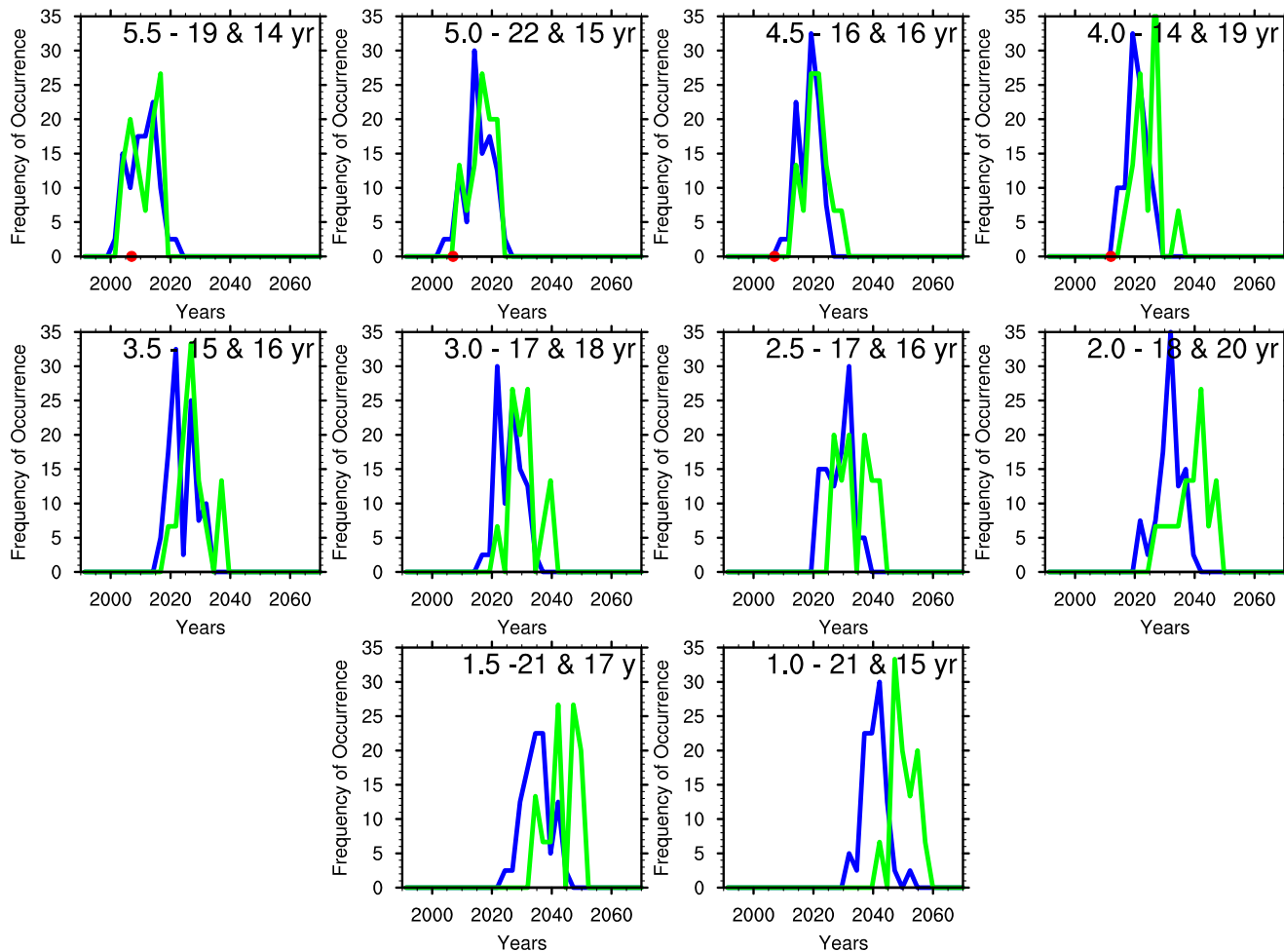
21 year (LE)
and 15 year
(ME)
uncertainty
range due to
internal
variability
alone

Other thresholds



Other thresholds & ME

Jahn et al., in prep

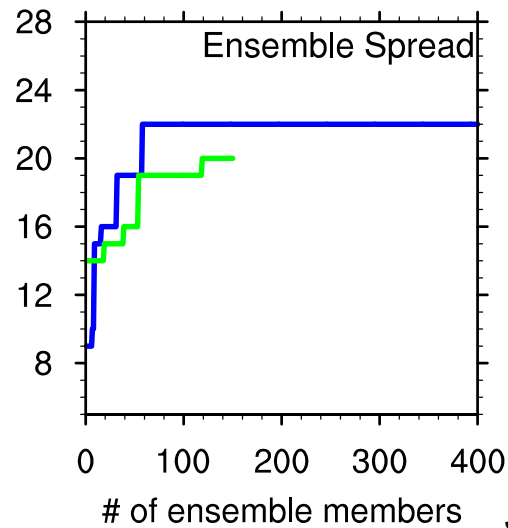
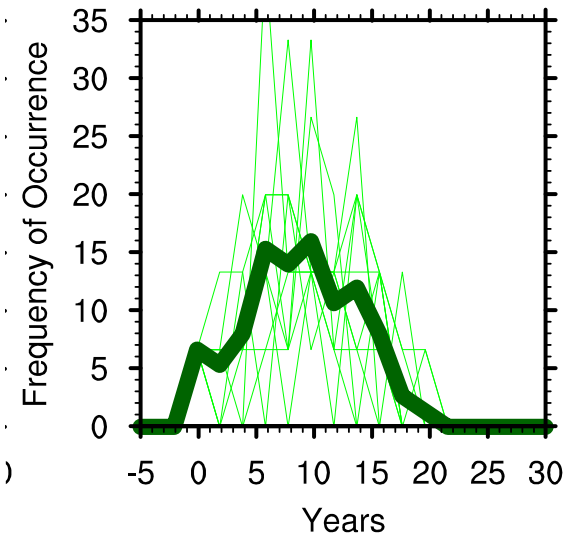
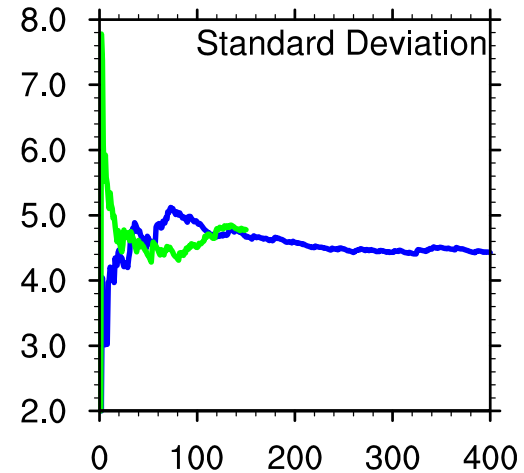
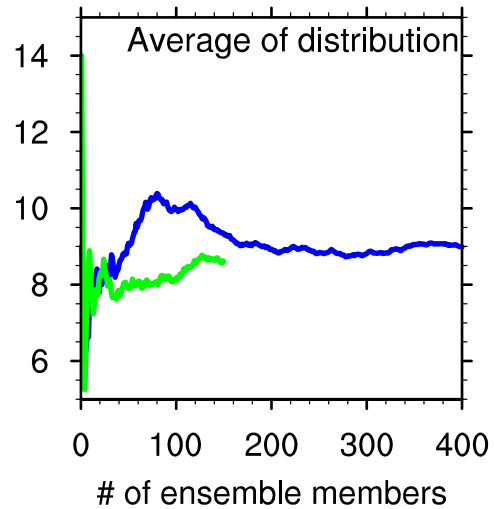
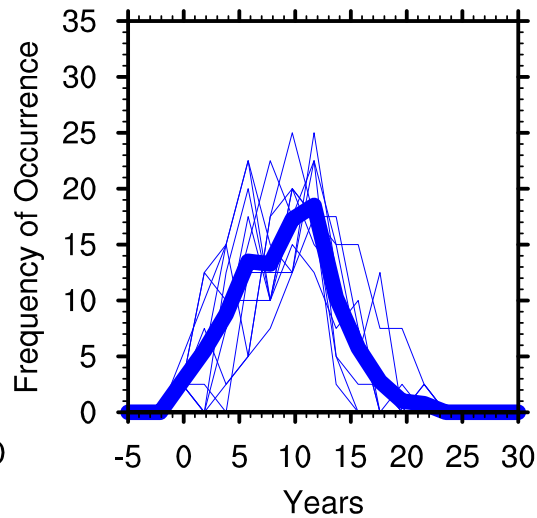


LE (RCP8.5)

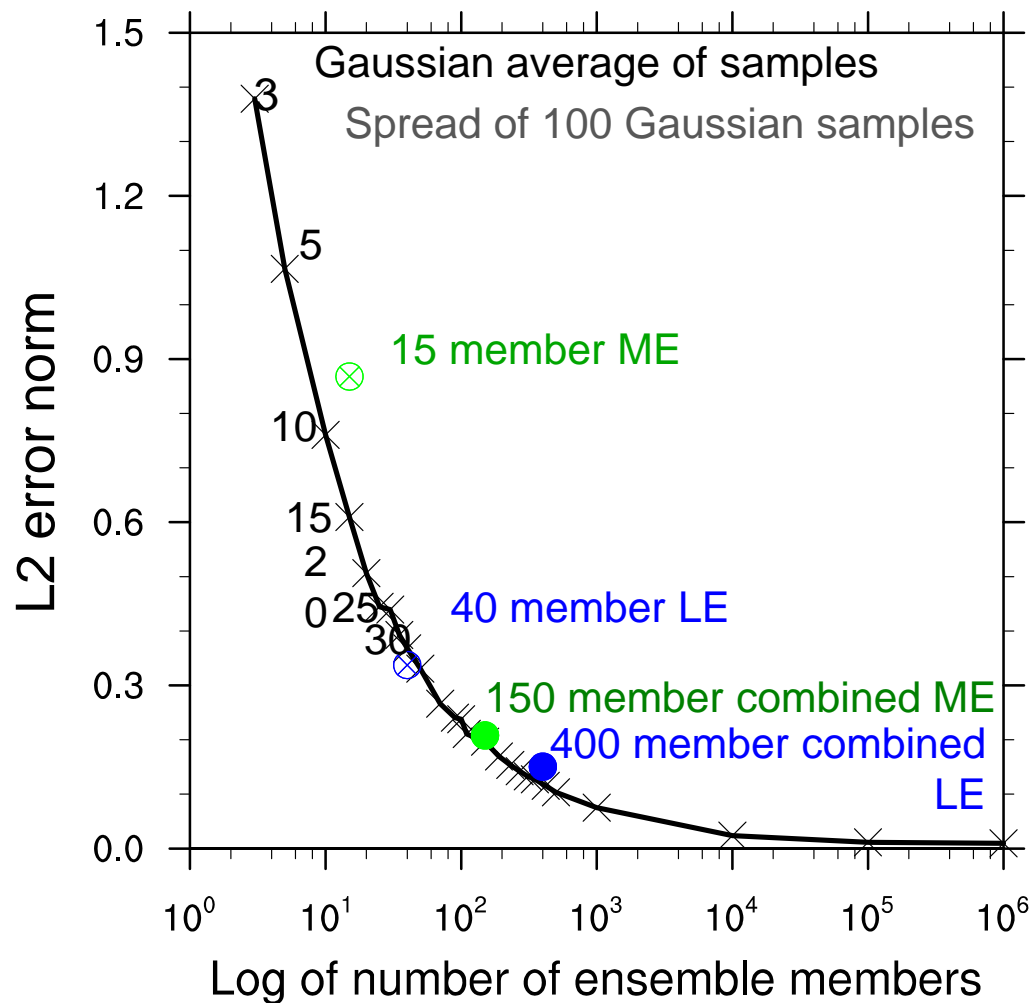
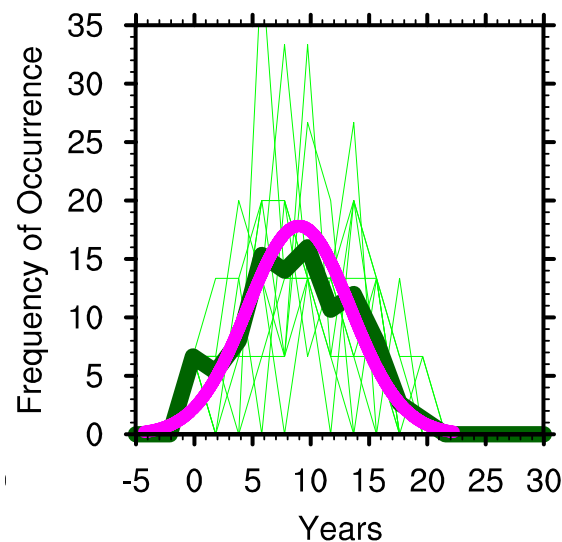
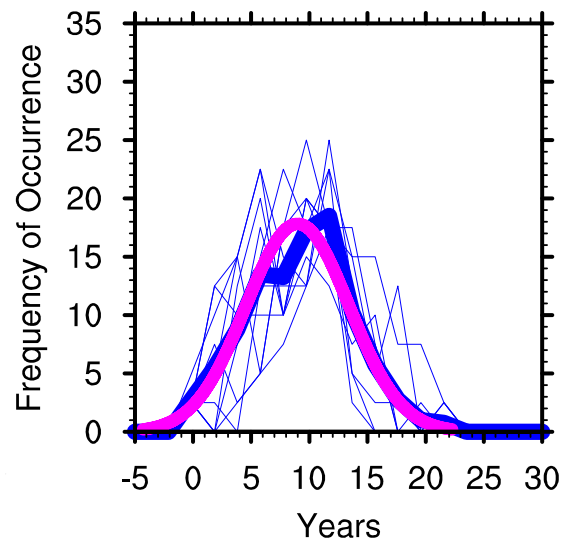
ME (RCP4.5)

Large uncertainty in prediction of threshold crossing due to internal variability

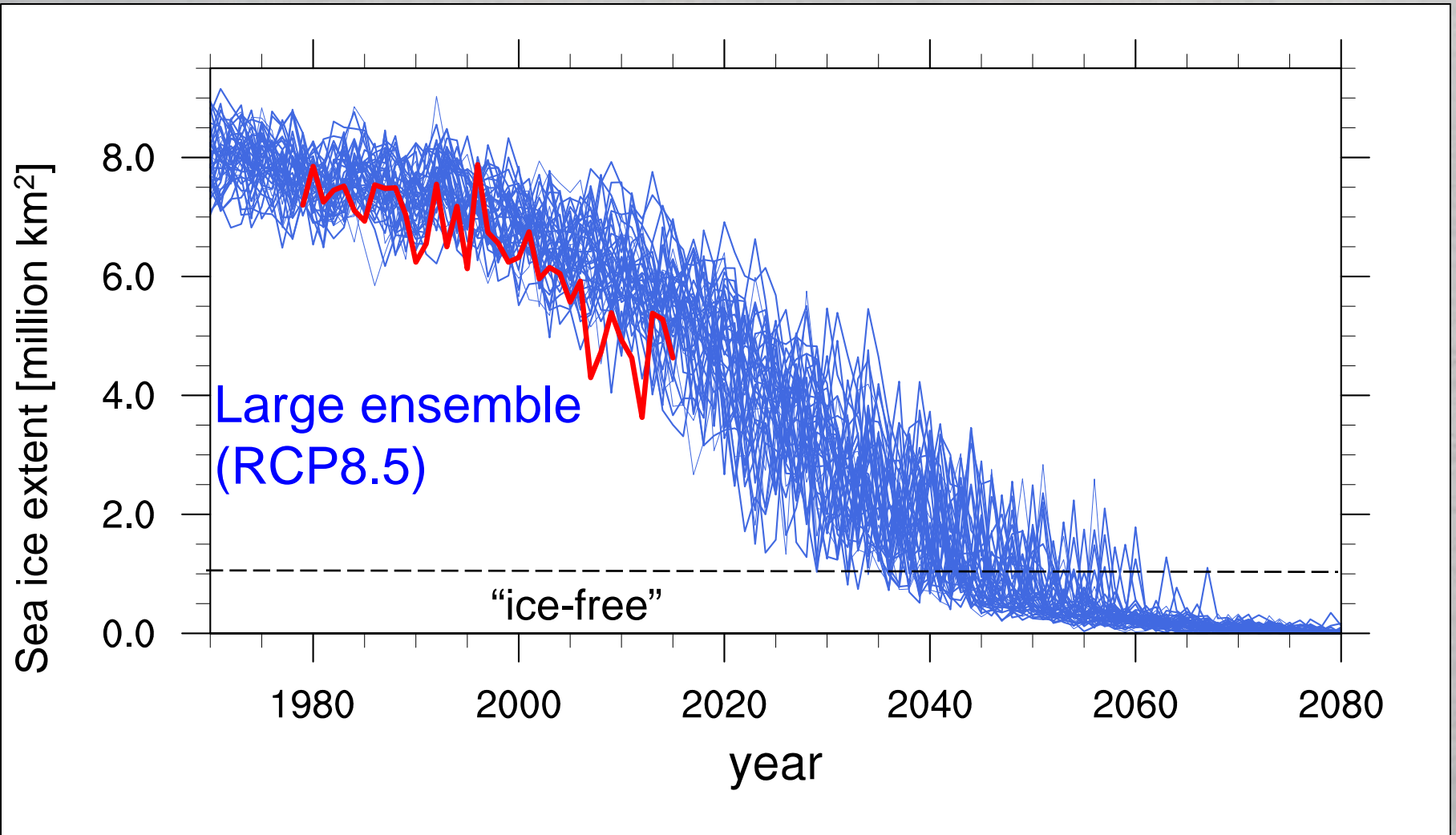
Are 40 members enough?



How many members do we need?



Can we tell which CESM trajectory is most likely, given present sea ice state?



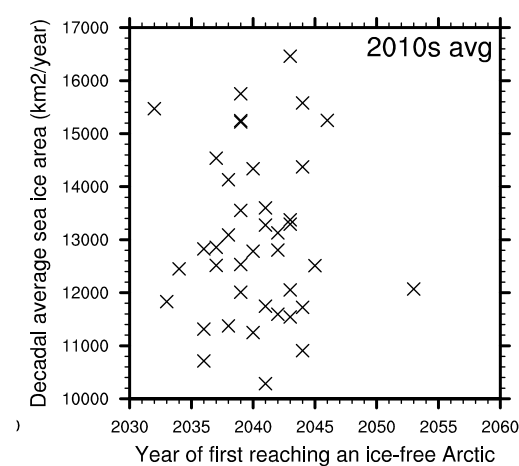
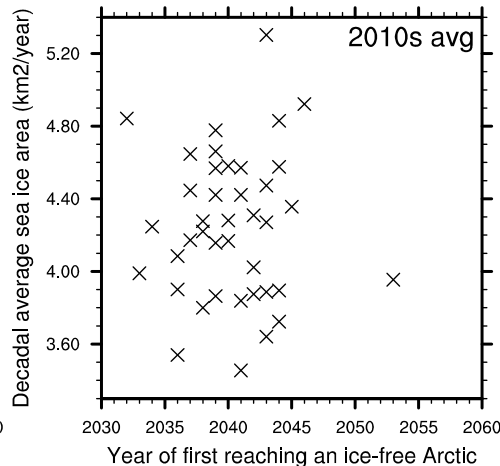
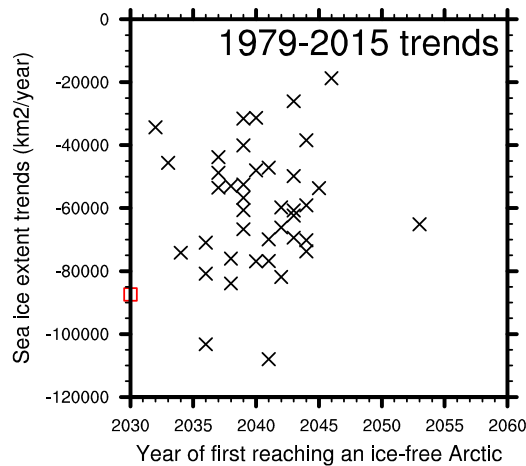
Any indication of which trajectory we are on, based on current sea ice state?

Sea ice extent trend versus ice-free year

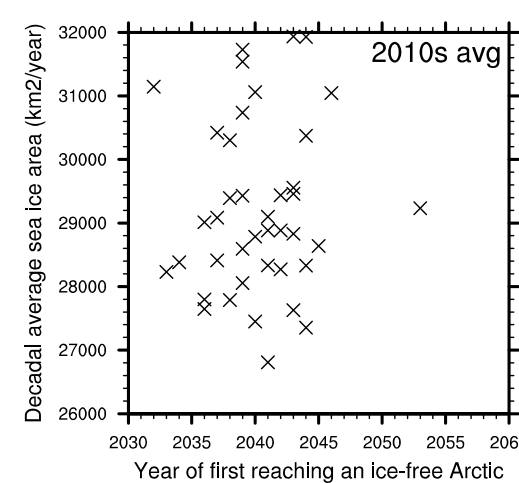
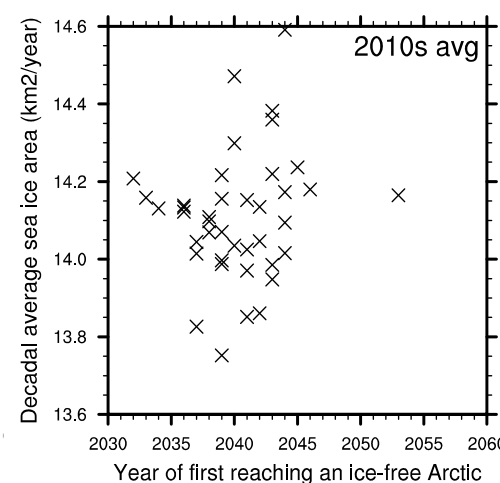
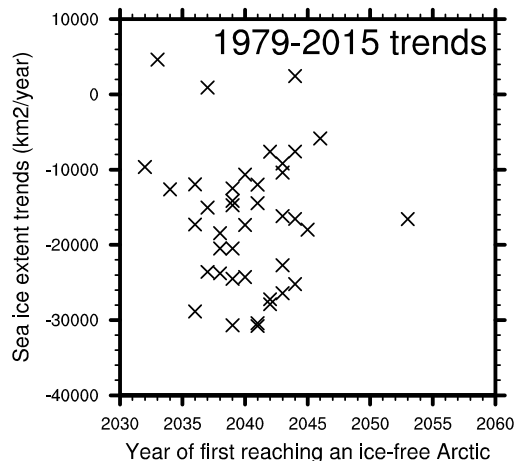
Decadal average sea ice area versus ice-free year

Decadal average sea ice volume versus ice-free year

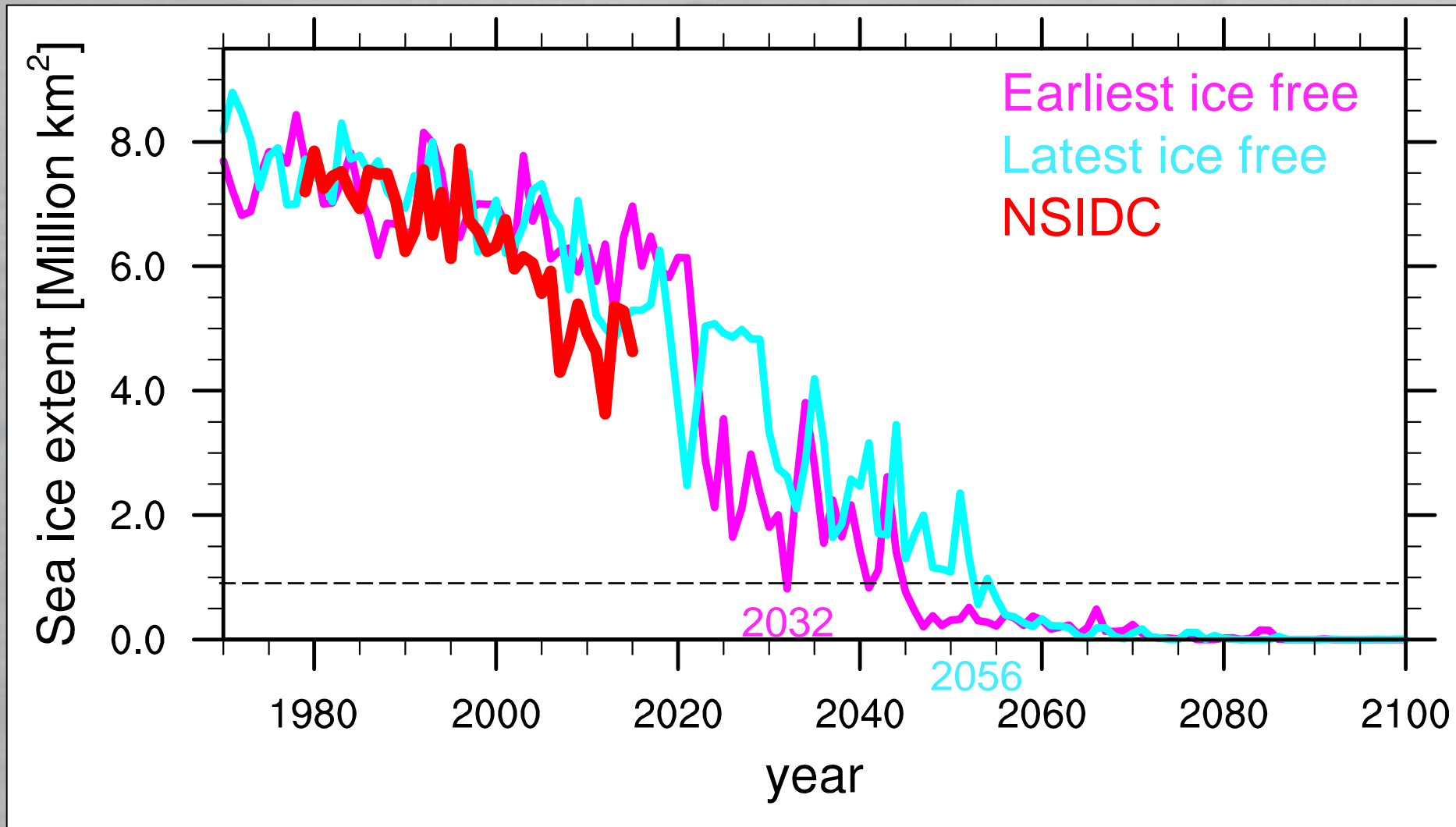
September



March



Trajectory of early versus late ice-free simulations

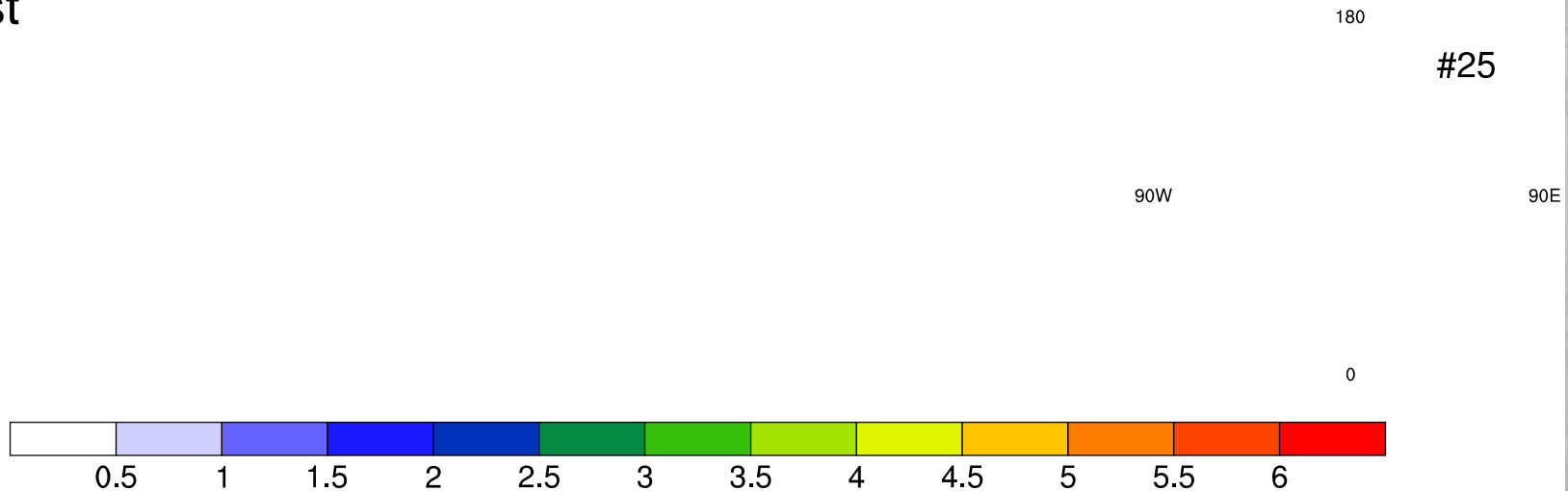


Sea ice thickness in early versus late ensemble members (Sept)

Latest



Earliest



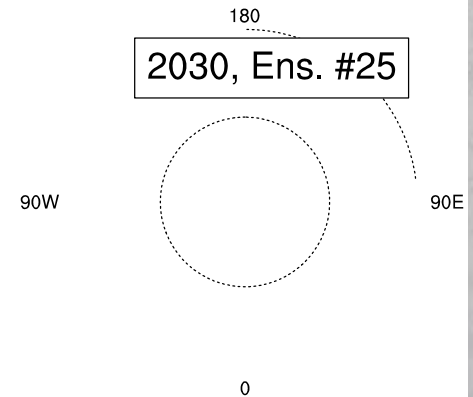
Ice thickness in 2015 or 2020 is no indicator for ice-free conditions in 2032 or later

Sea ice thickness in early versus late ensemble members (March)

Latest



Earliest



Ice thickness in 2015 or 2020 is no indicator for ice-free conditions in 2032 or later

Jahn et al., in prep

Summary

- Internal variability introduces uncertainty ~20 years to predictions of threshold crossing in the Arctic sea ice cover
- In CESM, uncertainty based on internal variability is larger than scenario uncertainty between RCP8.5 and RCP4.5
- A large number of ensemble members is needed to fully represent the distribution, but each addition member improves statistics of simulated climate
- The current sea ice state in CESM can not be used as an indicator of which ensemble member will be ice-free first